Flying Wire systems

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- Motivations
- Description of the systems
  - What we have and what we are setting up
  - Motion, timing
  - Loss monitors
  - DAQ
- Examples of the use of the systems
- Summary

Flying Wire System

- It consists of a can housing a rotating fork, whose rotation axis is offset with respect to the beam path. The fork (3.75-5.25 inches radius) holds a carbon wire of 30 μm diameter, which is made to move across the beam at a speed of ≳5 m/s.
- The spray of particles caused by the portion of beam hitting the wire is detected by a scintillator readout by a PMT. The PMT signal is gated in order to detect losses caused by the longitudinal section of beam of interest, integrated and digitized at each beam turn, together with the wire position measured by a resolver.
- A beam profile is reconstructed, with an accuracy on sigma of 10% or better.

Motivations

❖ Determination of transverse emittance from the measurement of the beam profile

$$\sigma^2 = \frac{\varepsilon^* \beta_{Latt}}{6\beta\gamma} + \left(D\frac{dp}{p} \right)^2 \qquad \varepsilon^* = \frac{6\sigma^2 \beta\gamma}{\beta_{Latt}}$$

❖ Monitoring transverse emittances during an acceleration cycle

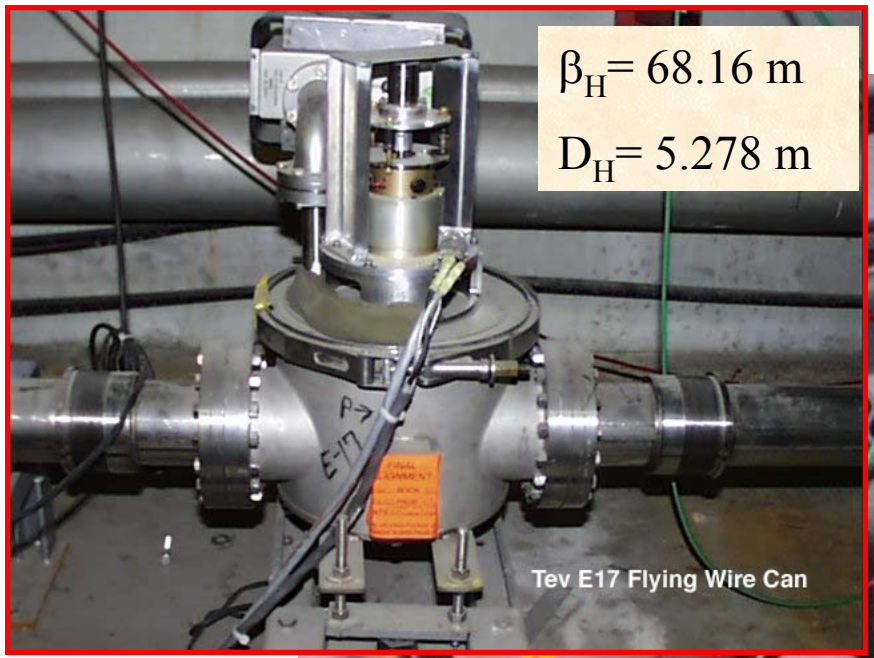
❖ Detect transverse emittance growth during transfers between different machines

➔ Understanding of emittances and emittance growth is crucial to improve performance of the accelerator complex

Flying wires in the different machines

- Presently operating
  - Two cans in Main Injector, horizontal and vertical, located at MI10 straight section, in negligible/small dispersion regions.
  - Three can in Tevatron, a horizontal and a vertical system at E11, and a horizontal system at E17.
- Being upgraded
  - Six wire systems in the Accumulator. Five of the wires, 3 horizontal and 2 vertical, are located in a single assembly unit at the AP40 high dispersion region. The sixth wire, horizontal, is located at the AP30 low dispersion region.
- Being built
  - Two cans in Recycler, horizontal and vertical, located at 620 and 619, respectively, in negligible dispersion regions.
  - Two cans for Ecool

The Tevatron system



The Main Injector system

The Recycler system

- During transfers between RR and MI it is necessary to preserve beam emittance and it is essential to have a system capable of detecting any emittance growth as small as 20%. The flying wires would be used, together with the system already present in MI, to detect emittance growth during beam transfers

- The system would also be used to measure transverse emittances of stacked beam in RR. With appropriate gating, it is possible to measure separately the hot and cooled section of the stacked beam

- In RR normalized transverse emittances from 40 π mm mrad down to 1 π mm mrad correspond to beam profiles with sigmas from 6 mm to 1 mm.

- **The system is being built to operate in a vacuum of 10^{-10} Torr.**

- The new mechanical system is being built by Technical Division. The plan is to be ready for installation in the "January shutdown". The commissioning of the whole system (electronics, DAQ, software) will probably take place about a month later.

- Technical Division will perform measurements of the resolution of the resolver system, both in static and dynamic mode.

Flying Wire System Configuration

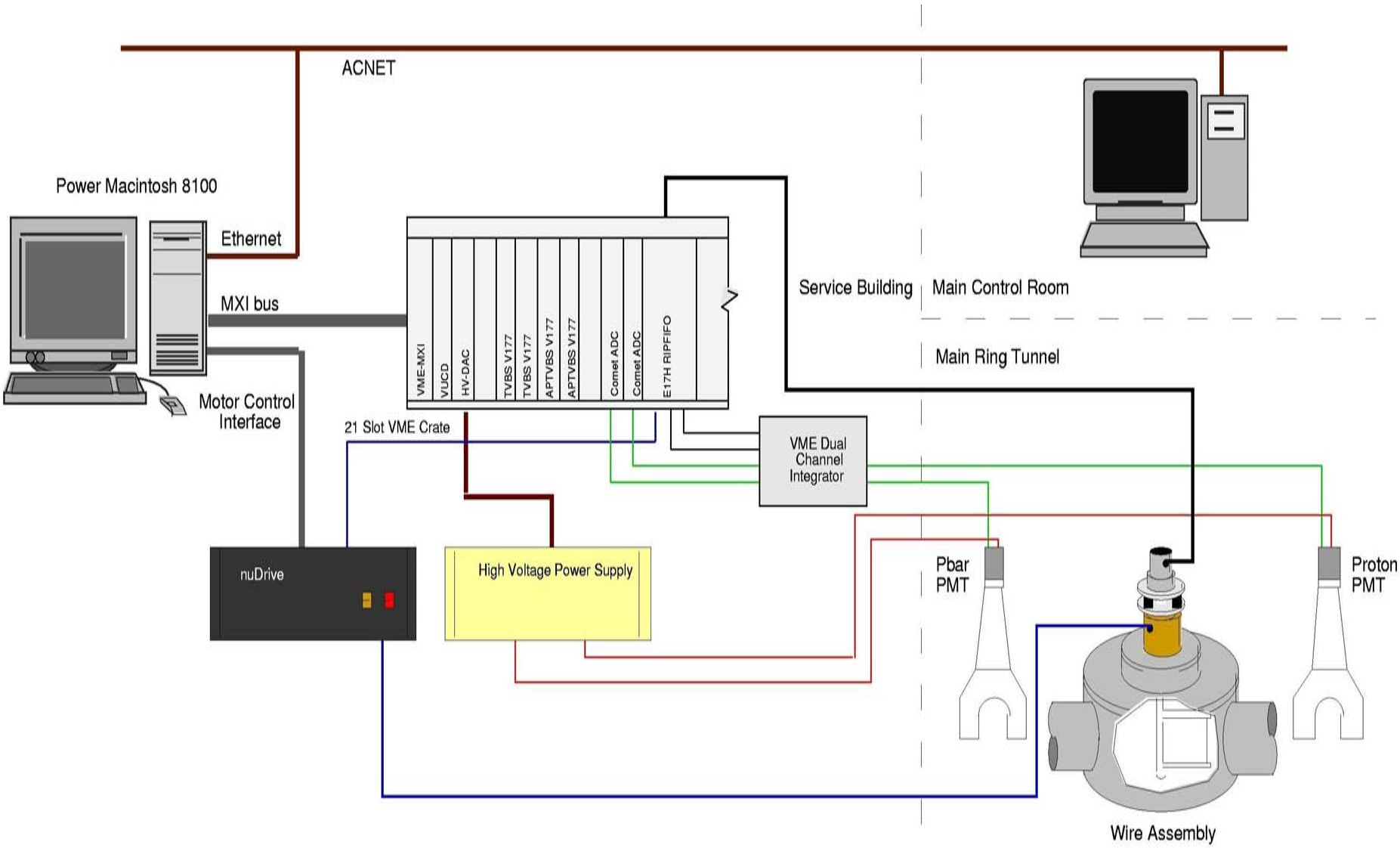
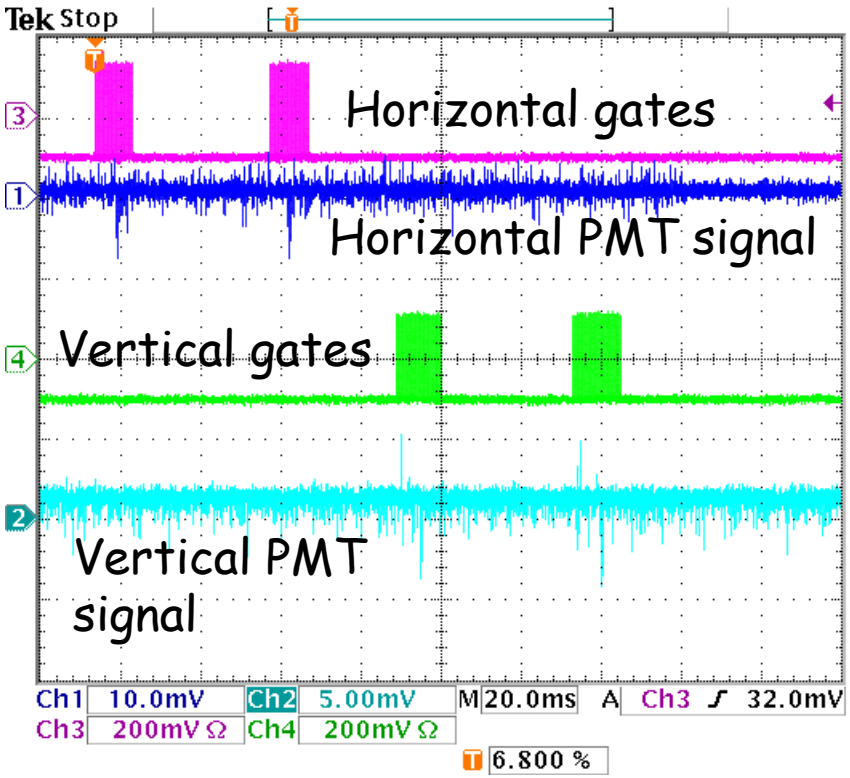
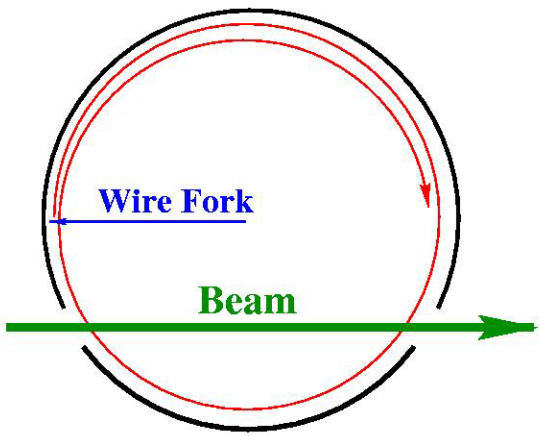
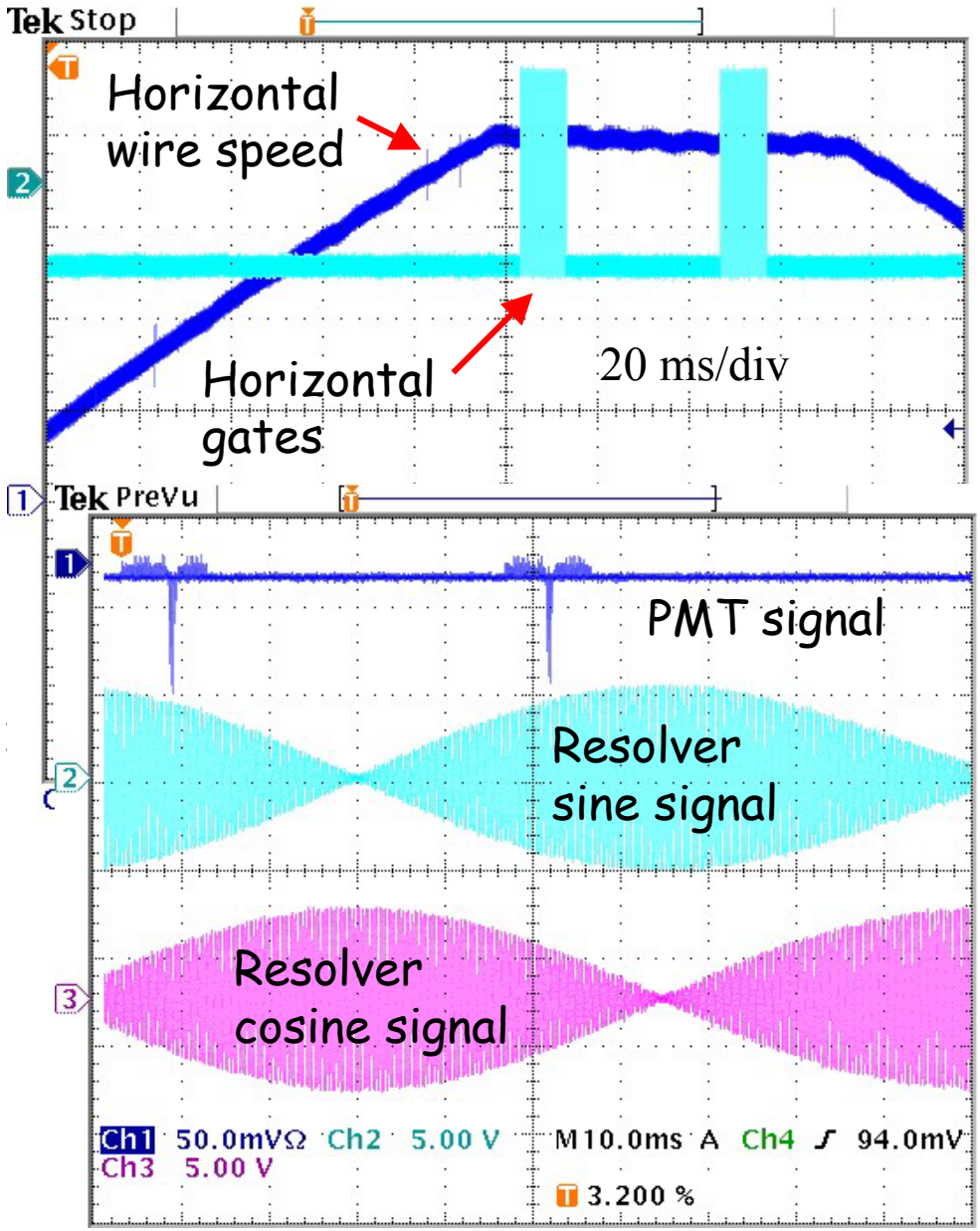


Figure 1. Single Wire Configuration.

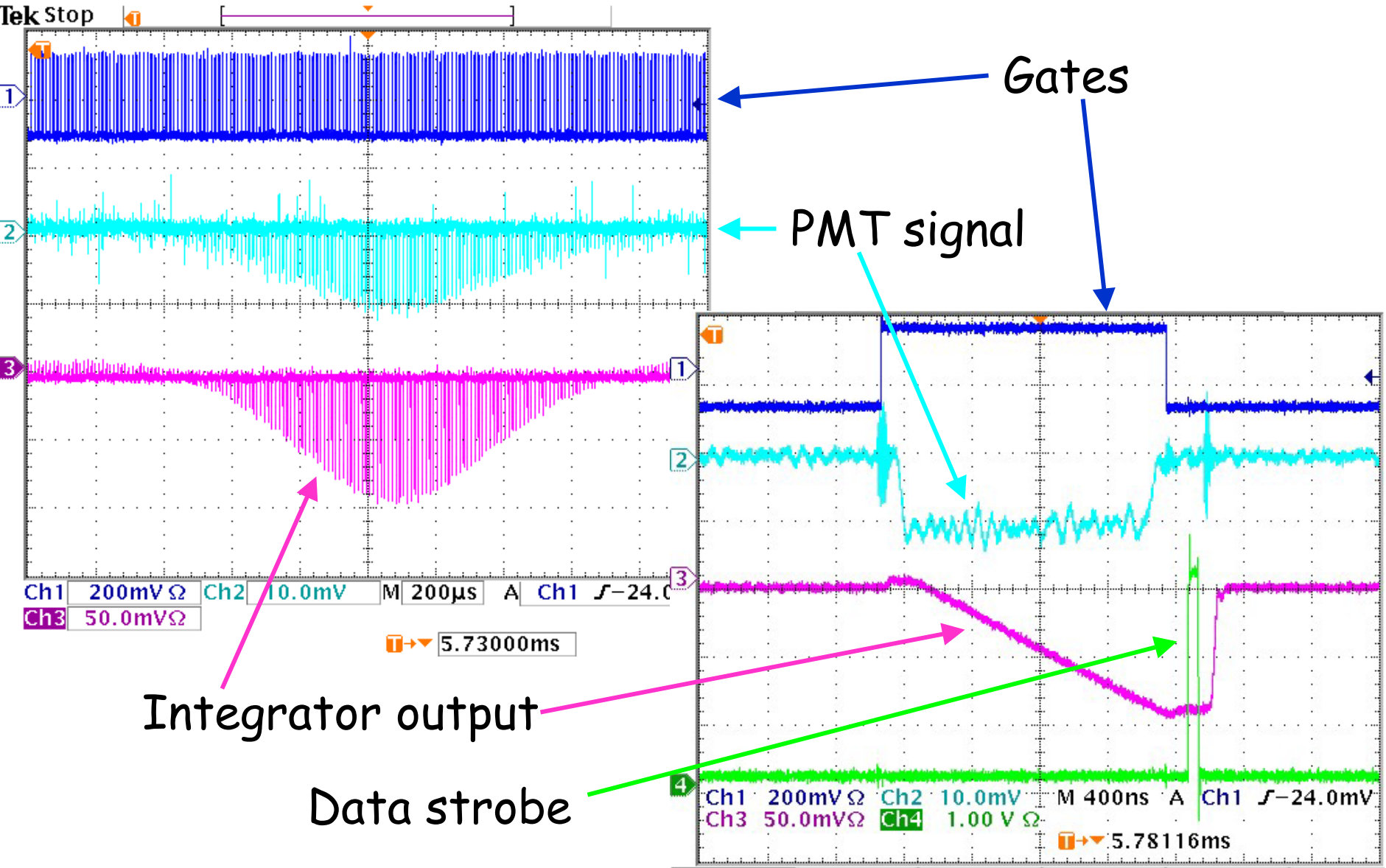
Motion, MI flying wire system



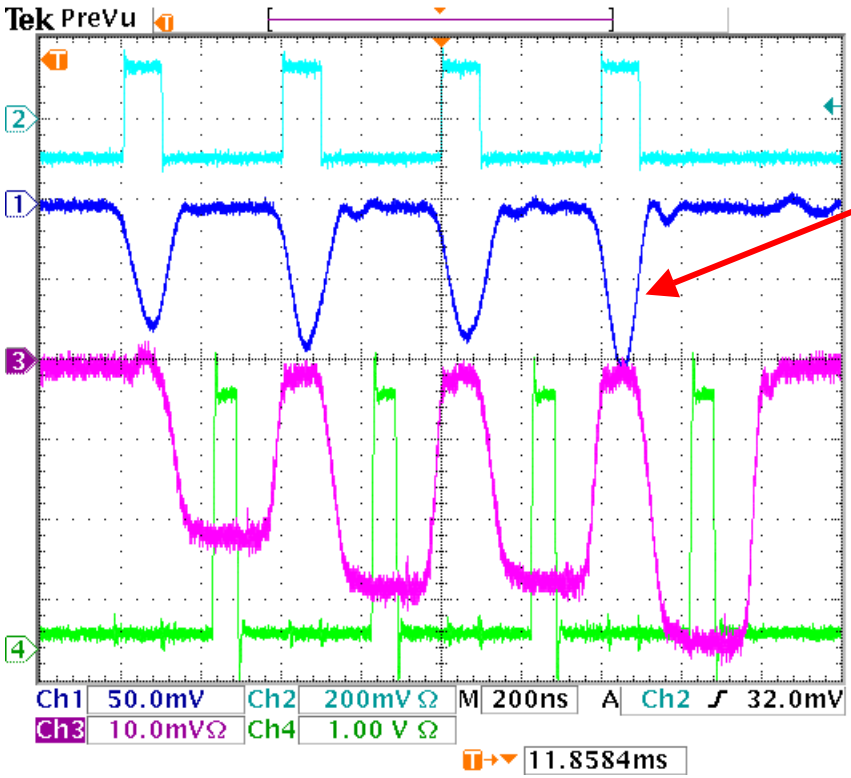




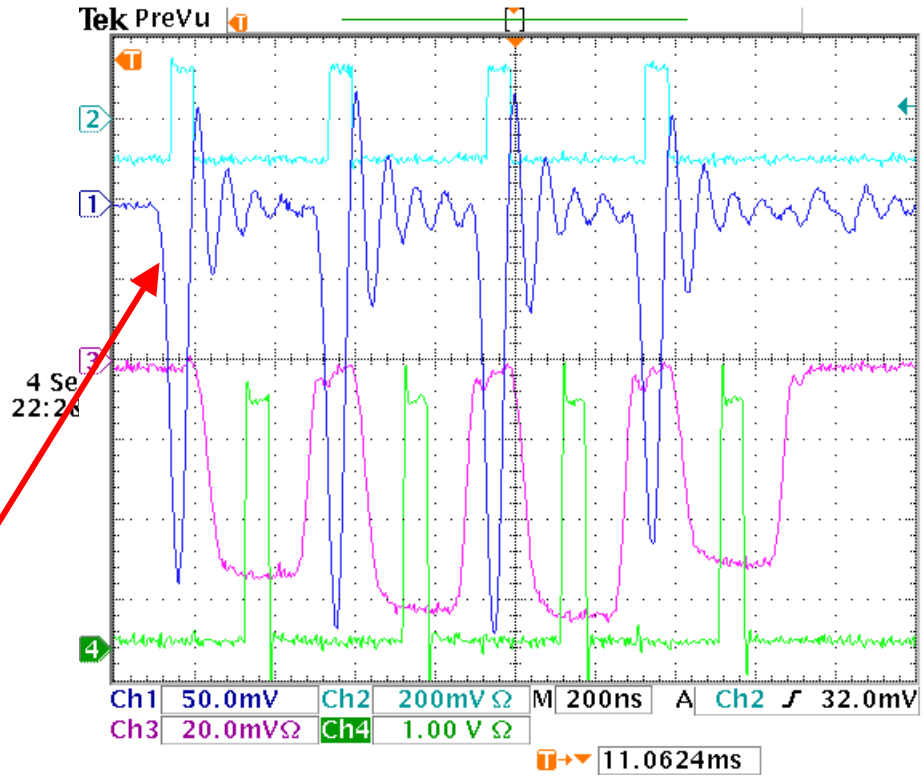
Timing, MI stacking cycle



Timing, $2A MI cycle: pbar transfer to Tevatron



4 batches (each of 7-13 53 MHz bunches) of $\bar{p}$ @ 8 GeV, separated by 21 RF buckets



4 coalesced bunches of $\bar{p}$ @ 150 GeV

Loss monitors

➥ Intensity increase in machines requires loss monitors to cover a larger dynamic range.

❖ The present system uses a Philips XP2203B (we use 5 stages out of 10), and it is at the limit of the dynamic range that can be covered by adjustment of the high voltage.

❖ With help from Technical Division (Y. Pischalnikov) and PPD (C. Lindenmeyer)

- ➥ use 6 stage Hamamats R5380, with reasonably low gain (~5000) and large output current capability, designed for SSC calorimetry applications
- ➥ use remotely placeable light attenuators to increase dynamic range

DAQ and Analysis

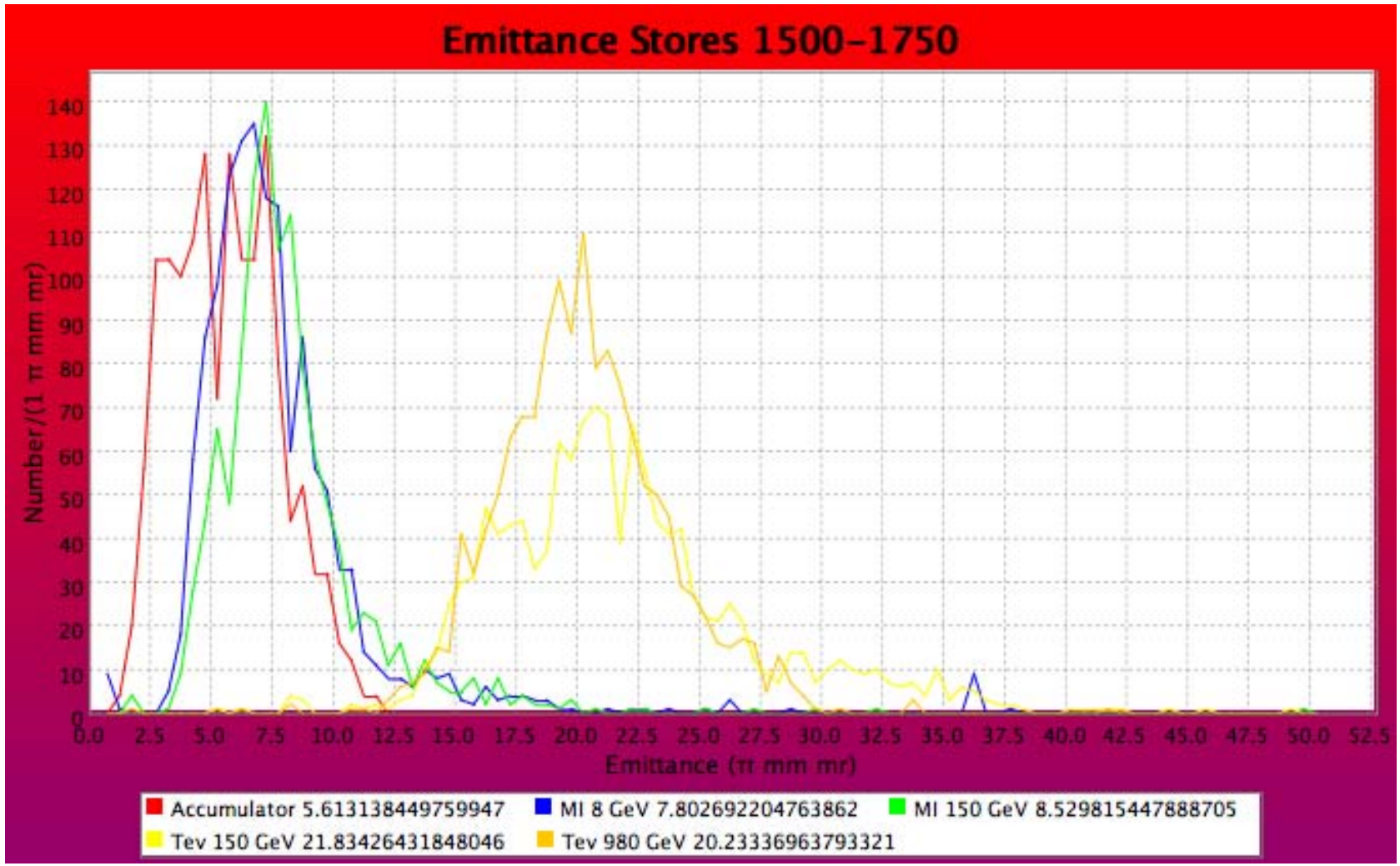
- LabView application program running on a Macintosh:
  - motor control and position signal readout
  - setup and readout of loss monitors
  - online analysis ⇨ emittance values
  - data transfers and ACNET interface

➥ ***Move program to a PC and clean it up***

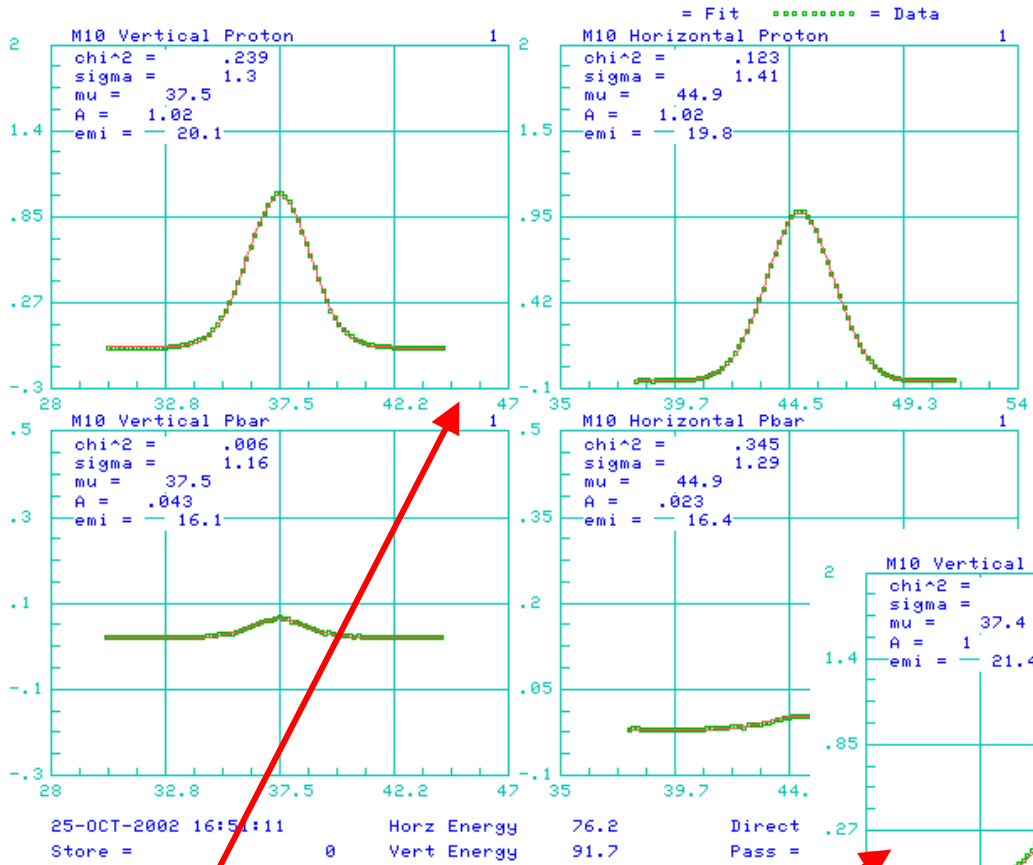
- **All of the flying wire data acquired during shots to the Tevatron is recorded into SDA and there analyzed.**

Pbar transverse emittances from SDA

Paul Derwent

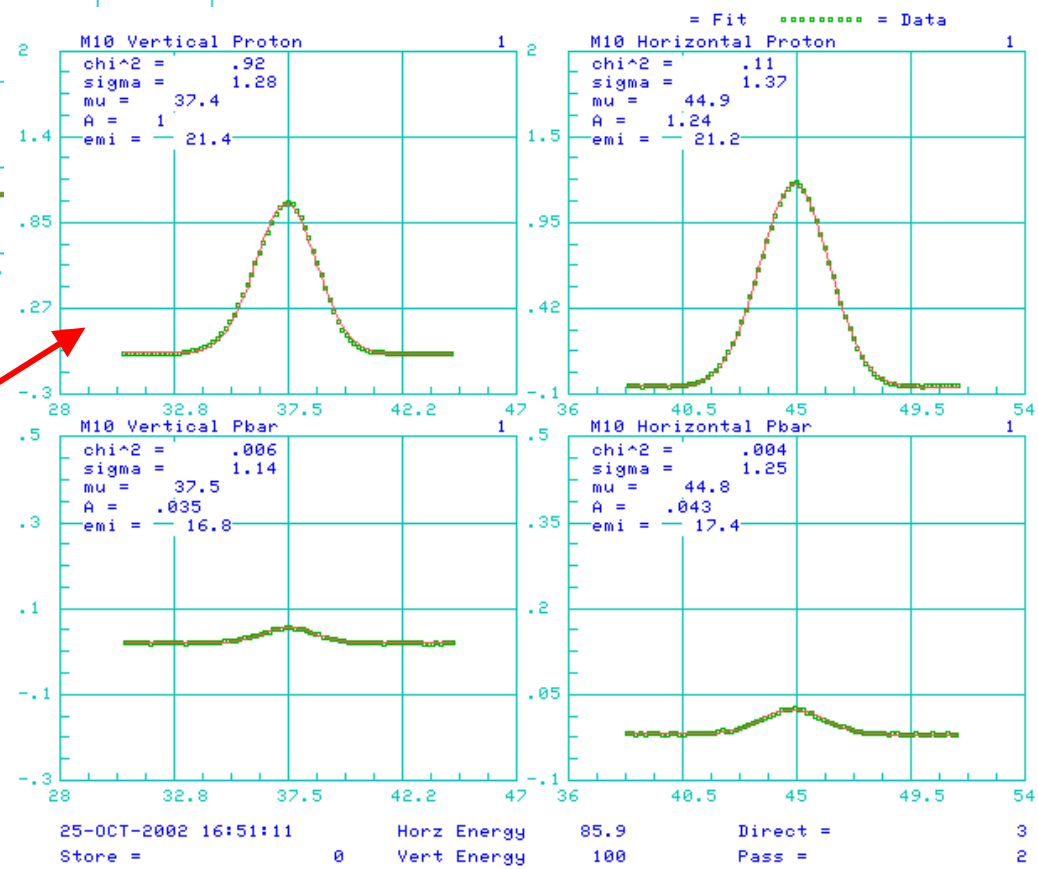


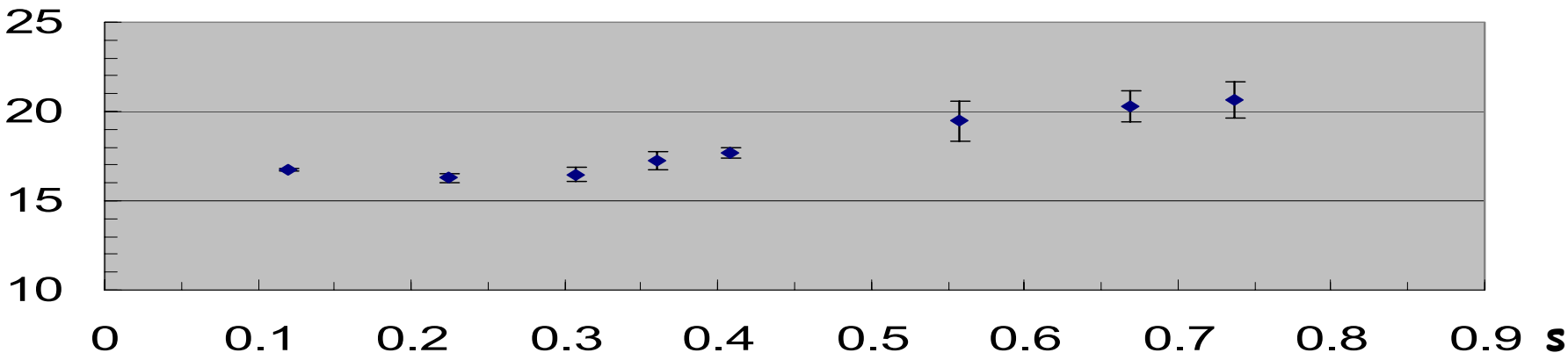
MI transverse emittance on pbar stacking cycle



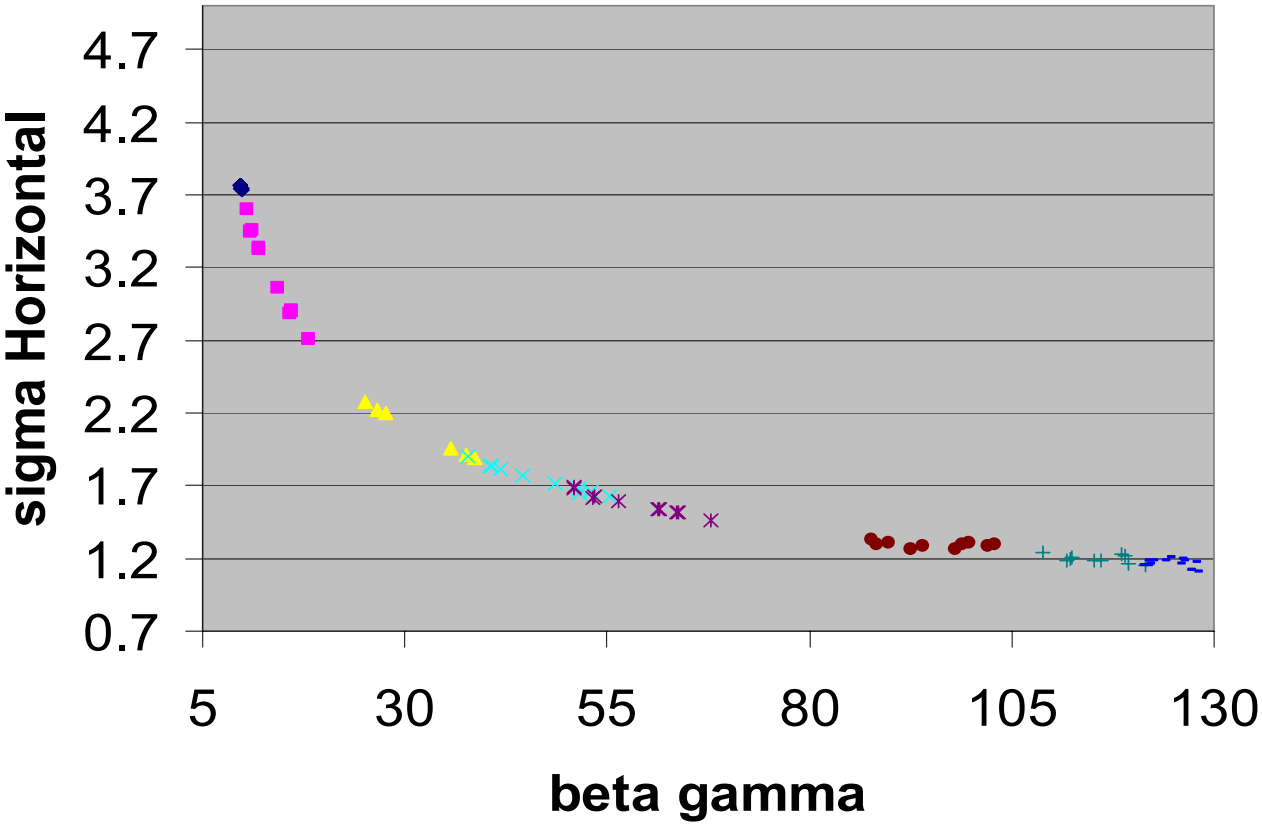
1st pass

2nd pass



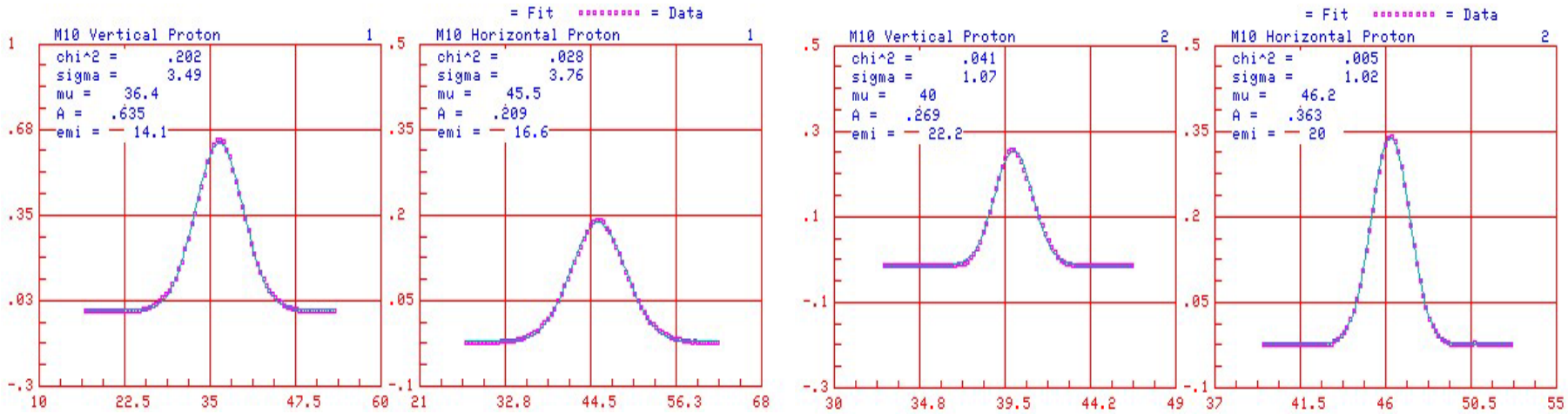


MI transverse emittance on pbar stacking cycle

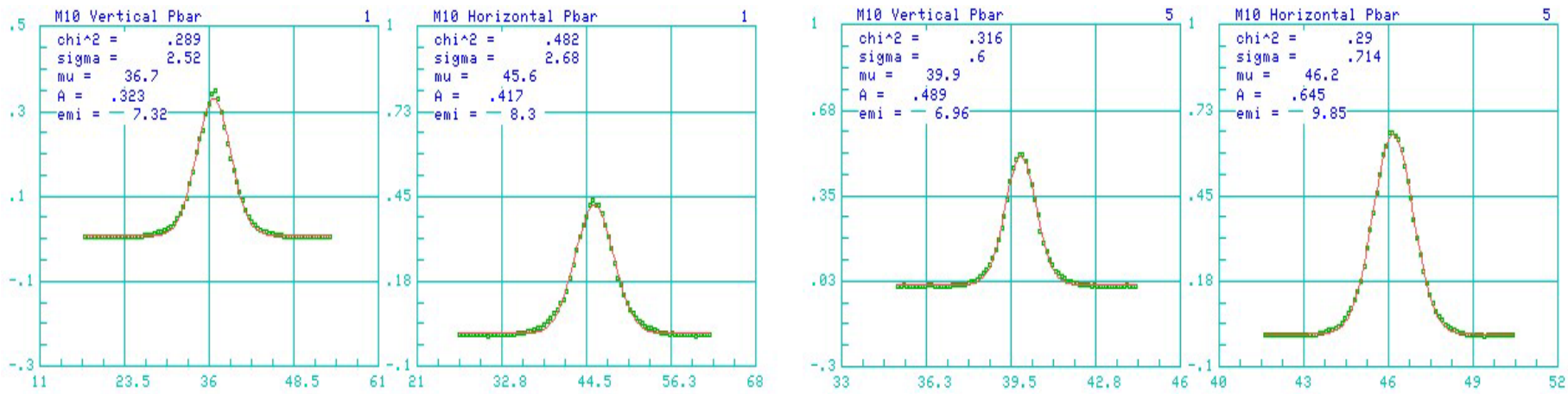


MI, p & $\overline{p}$ shots to the Tevatron

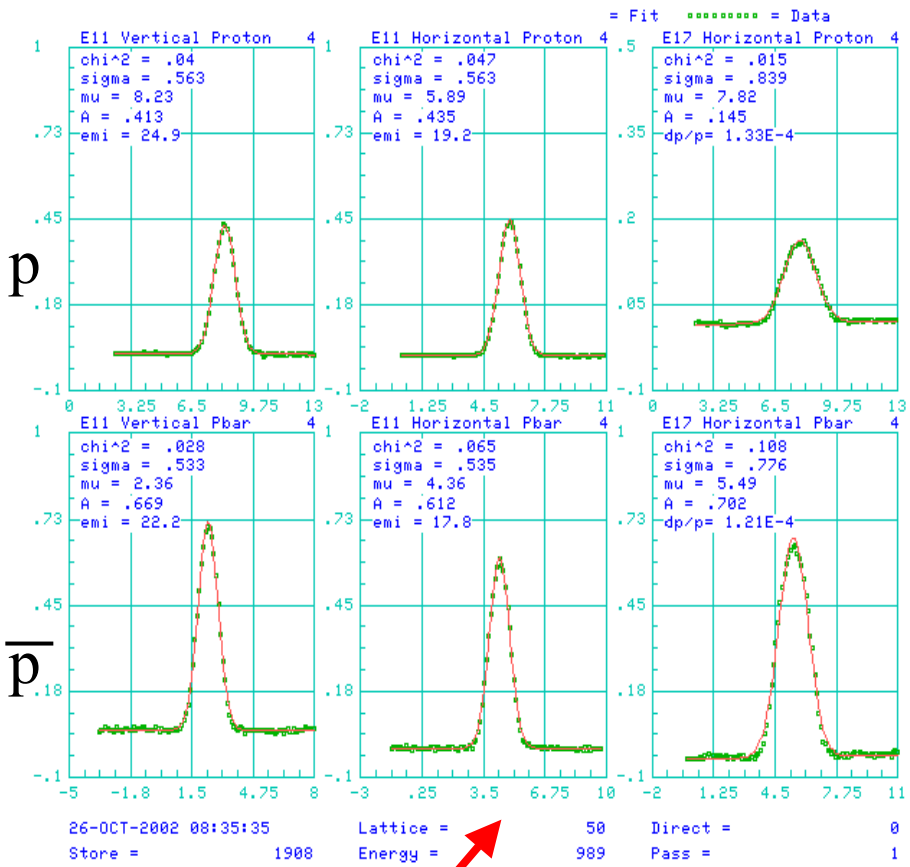
8.9 GeV **Protons** 150 GeV



Antiprotons



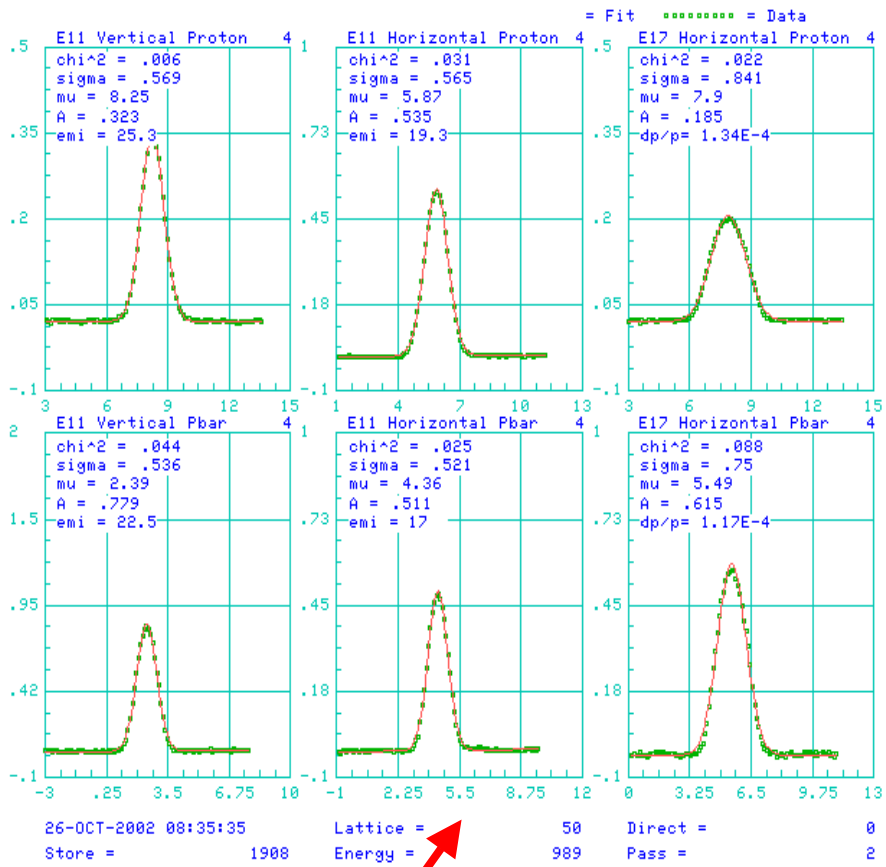
Tevatron Flying wires @ 980 GeV



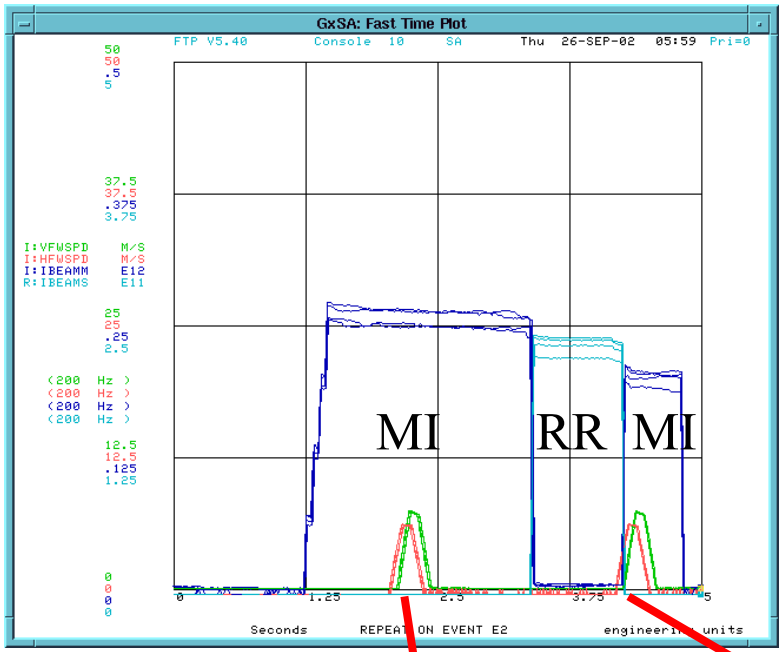
p

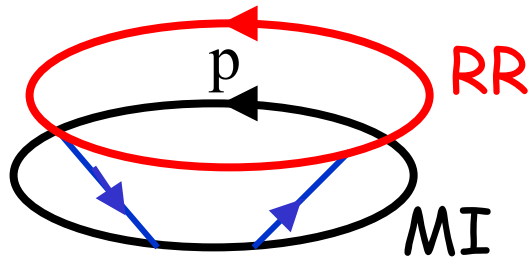
$\overline{p}$

1st pass

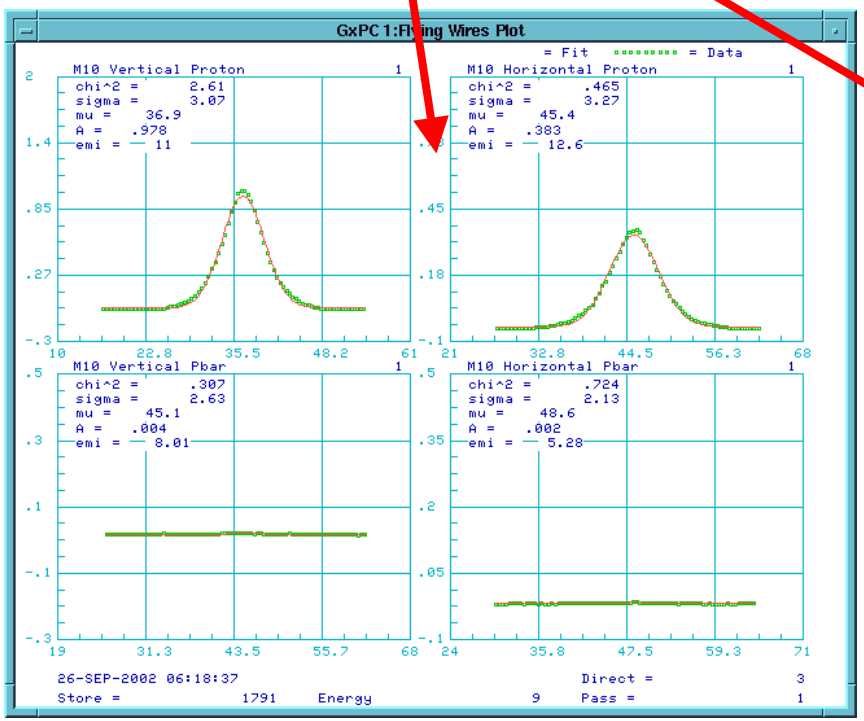


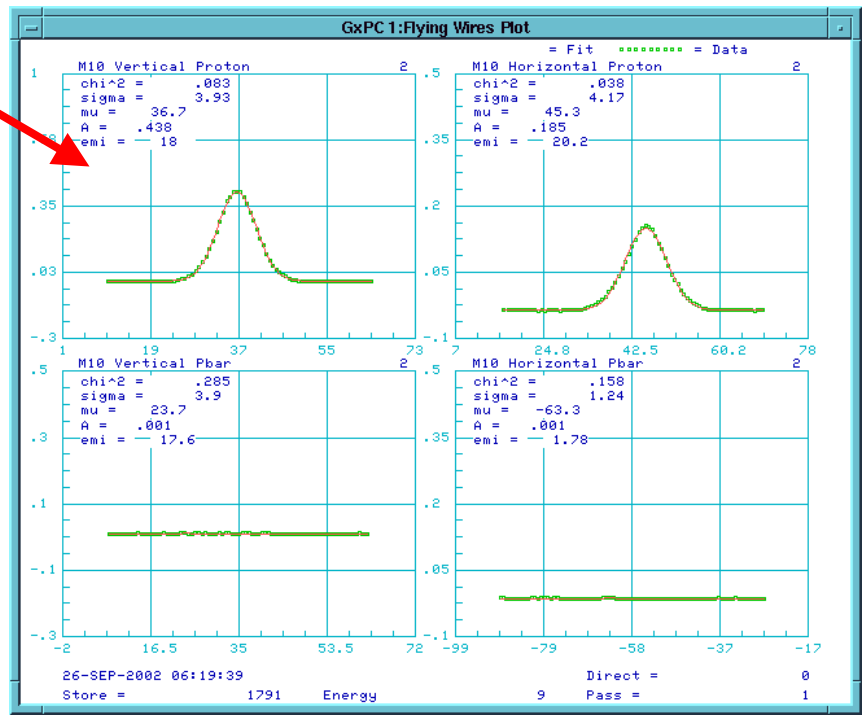
2nd pass





Transverse emittance increase in MI → RR → MI





Summary

- Different systems throughout the accelerator complex, presently operating, being upgraded or built.
- Main Injector and Tevatron systems provide invaluable information in the day by day operation of the accelerator complex
  - flying wire data are an essential part of the information recorded in SDA
- Efforts are underway to better understand accuracy and systematic errors of the systems
- Loss monitors being upgraded